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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A61B 5/05 | A1

(11) International Publication Number: WO 97/01303

(43) International Publication Date: 16 January 1997 (16.01.97)

(21) International Application Number: PCT/KR96/00092

(22) International Filing Date: 19 June 1996 (19.06.96)

(30) Priority Data:
1995/17226 24 June 1995 (24.06.95) KR

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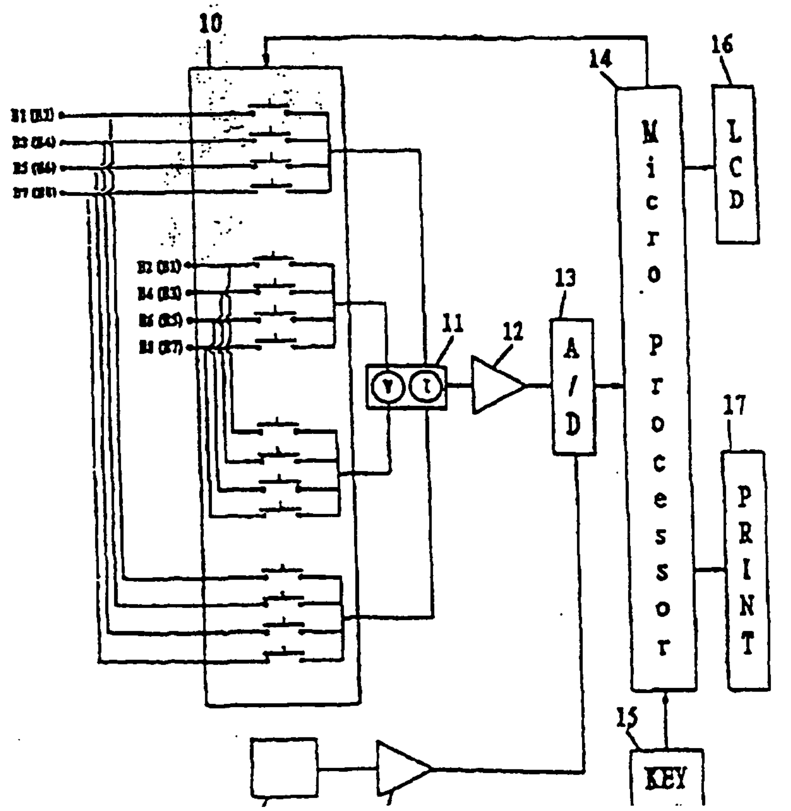
(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: APPARATUS AND METHOD FOR ANALYZING BODY COMPOSITION USING A NEW ELECTRODE SYSTEM BASED ON BIOELECTRICAL IMPEDANCE ANALYSIS

(57) Abstract

An apparatus for analyzing body composition based on bioelectrical impedance analysis, and a method therefor are disclosed. The method for analyzing body composition includes the step of providing eight electrodes E1-E8 for being contacted to a right palm, a right thumb, a left palm, a left thumb, a right front sole, a right rear sole, a left front sole and a left rear sole. A switch (10) is selected by a command of a micro-processor (14) so as to form a current path. A current is made to flow through said selected electrodes and through a human body to an impedance measuring instrument (11). A switch (10) is selected by a command of said micro-processor (14) so as to form voltage electrodes. Impedances for respective body segments are measured by means of the impedance measuring instrument (11) on the basis of the current and voltage of the impedance measuring instrument (11). Then the body composition is analyzed from the measured impedances.



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APPARATUS AND METHOD FOR ANALYZING BODY COMPOSITION USING A NEW ELECTRODE SYSTEM BASED ON BIOELECTRICAL IMPEDANCE ANALYSIS

Field of the Invention

The present invention relates to an apparatus for analyzing body composition based on bioelectrical impedance analysis, and a method therefor. Particularly, the present invention relates to an apparatus for measuring segmental impedances of the body by contacting the hands and the feet to novel metal electrodes, and a method for measuring segmental impedances of the body and quantitatively analyzing body composition such as body fluid, body fat, and the like.

Background of the Invention

A human body is composed of water, protein, bone and fat, in addition to small amounts of segmental components. The total of these elements constitutes the body weight. Quantitatively measuring the respective element is called body composition analysis. The proportion occupied by the fat is called fatness and the proportion occupied by the fat free mass (FFM) is called leaness. In the medical terms, of the body composition, fat free mass (FFM) is the main component for supporting the human body. Patients who are related to the malnutrition such as cancer and hemodialysis are subjected to a periodically measuring the amount of FFM to know the state the malnutrition. In the case where a fatty man performs athletic exercises to reduce the body weight, it frequently happens that the body weight shows little variation within a relatively short period of several months. In this case, if the body composition is

will be found that the amount of muscle has increased, although the amount of fat has been decreased. In this way, the effect of the athletic exercise can be checked in a rational manner. Further, based on the analysis of the body composition, the growth of children and the nutritional status of elderly men can be diagnosed. Particularly, the segmental water distribution can be measured to determine patient's hydration status.

There are various conventional methods for measuring the body composition. One of them is hydrodensitometry, and this method is carried out in the following manner. That is, the human body is immersed into water, and in this state, the body weight is measured. Then based on the density of the human body, the amount of fat is calculated. This method is based on the principle that fat is lighter than FFM. Hydrodensitometry shows a high accuracy, and therefore, it is used as a standard method. However, it has the disadvantage that it is a troublesome task to carry it out, and thus cannot be applied to an elderly man or to a patient.

Another conventional method is to measure the thickness of the subcutaneous fat layer by using a caliper. This method has the disadvantage that the accuracy is low.

Further, there are photographic methods such as nuclear magnetic resonance (NMR), and dual energy X-ray absorptiometry (DEXA), and dilution methods such as heavy water (D_2O) and sodium bromide dilution. However, these methods are expensive to carry out, and therefore, they cannot be generally applied to patients in an economical manner.

As another method for measuring the body composition, there is bioelectrical impedance analysis (BIA). This method has advantages that it is safe compared with the other conventional methods, the cost is low, and the measurement is done in a fast manner. This method

is carried out in the following manner. That is, a weak alternating electrical current is passed across the human body to measure the electrical resistance or conductance of the body. The height and weight are measured additionally. Based on these measured values, the amount of the body fluid, the fluid balance inside and outside the cell, and the amount of the body fat are calculated.

In U.S. Patent No. 5,335,667, the analysis method based on the bioelectrical impedance is carried out in the following manner. That is, in a state with a patient lying, contact electrodes are attached on the skin of the body. The electrodes are adhesive electrodes which are similar to the electrodes for the electro-cardiogram.

In the conventional method, four electrodes which are similar to the electrodes for the electro-cardiographic (ECG) test are attached on the wrist, back of hand, ankle and back of foot, thereby electrically connecting the human body to an impedance measuring instrument. Then an electrical current is let to flow, and then, the resistance between the wrist and the ankle is measured.

In this method, in a state with a human body lying, the electrodes are attached to the skin of the human body, and then, the impedance of the human body is measured. Then based on the measured values, the results such as percent body fat and FFM are obtained by using a BIA equation Therefore, this method can be carried out only by employing a particularly trained person. Therefore, it is difficult to be used in public place such as saunas, athletic rooms and the like.

Further, in this method, the impedances of the body segments such as arm, trunk and leg are difficult to be separately measured, and therefore, the difference between individuals in the regional impedance distribution causes a measurement error without segmental information.

Further, in this conventional method, the measuring person attaches the electrodes to the body portions of the person to be measured, and therefore, the attachments are not always done to the exact position, thereby generating measuring errors.

Further, if hairs exist on the attachment positions, there is the inconvenience that the hairs have to be removed before attaching the electrodes.

Further, this conventional method has the inconvenience that the body impedance is measured, and then, a computer is used to calculate the fat proportion. That is, the measuring person has to attach the electrodes to the relevant positions of the body of the person to be measured, the body weight and the body height have to be measured separately, and then, a computer has to be used to calculate the fatness. Therefore, it takes about 5 to 10 minutes in carrying out the measuring and analyzing.

In an attempt to overcome the above described disadvantages of the conventional techniques, the present inventor developed an apparatus for analyzing body composition and a method therefor, and filed a patent application under Korean Patent Application No. 94-23440 filed September 15, 1994.

The present invention is an improvement of the above invention, in which the different segments of the body impedance can be measured and analyzed in a convenient and precise manner.

Objects of the Invention

Therefore, it is an object of the present invention to provide an apparatus for analyzing the body composition by measuring the bioelectrical impedance, in which the body composition can be analyzed in a simple and convenient manner even without a specially trained person, like when measuring body weight on an electronic scale.

It is another object of the present invention to provide an apparatus for measuring the body impedance, in which a person can attach his palms of hands and his soles of feet to the metal plate electrodes without an assistance of other people, thereby quickly and conveniently connecting an impedance measuring apparatus to the body.

It is still another object of the present invention to provide an apparatus for precisely measuring the segmental body impedance by attaching the palms of hands and the soles of feet to 8 metal plate electrodes.

It is still another object of the present invention to provide an apparatus for analyzing the body composition, in which the body weight can be simultaneously measured.

It is still another object of the present invention to provide an apparatus for analyzing the body composition, in which the composition analysis results can be known through a display unit, and can be printed immediately.

Summary of the Invention

In achieving the above objects, the apparatus for analyzing the body composition based on the bioelectrical impedance analysis according to the present invention includes:

a plurality of electrodes E1-E8 for contacting with a right palm, a right thumb, a left palm, a left thumb, a right front sole, a right rear sole, a left front sole, and a left rear sole respectively;

an impedance measuring instrument 11 for measuring the impedance based on a voltage-current ratio after making an alternating current flow between two of the electrodes and by reading the voltage difference;

an electronic switch 10 for being controlled by a

micro-processor 14 to select electrical connections between the electrodes E1-E8 and the impedance measuring instrument 11;

a weight measuring sensor 18 for measuring the body weight of the person to be measured;

a keyboard 15 for inputting the body height, age and sex of the person to be measured;

an A/D converter 13 and amplifiers 12 and 19 for interfacing the impedance measuring instrument 11 and the weight sensor 18 to the micro-processor 14;

the micro-processor 14 controlling the electronic switch 10 and processing the data received from the impedance measuring instrument 11 and the keyboard 15; and

a display unit 16 for displaying the results.

In the body composition analyzing apparatus of the present invention, the results processed by the micro-processor 14 are displayed on the display unit 16, and when needed, a printer 17 is added for printing the data.

In another aspect of the present invention, the method for measuring the body impedance according to the present invention includes the steps of:

contacting a right palm, a right thumb, a left palm, a left thumb, a right front sole, a right rear sole, a left front sole and a left rear sole to eight electrodes E1-E8;

measuring segmental impedances by means of an impedance measuring instrument 11 by selecting "on" or "off" of electronic switch 10 which is controlled by a micro-processor 14;

measuring body weight by means of a weight measuring sensor 18;

inputting body height, age and sex through a keyboard 15; and

measuring an amount of body fluid (TBW), an amount of fat

free mass (FFM), a percent body fat (%BF) and a distribution of body fluid (ECW/ICW), by means of the micro-processor 14.

The results of the analysis can be displayed on a display unit 12 or can be printed through a printer 14.

Brief Description of the Drawings

The above objects and other advantages of the present invention will become more apparent by describing in detail the preferred embodiment of the present invention with reference to the attached drawings in which:

FIG. 1 is a schematic view showing a person measuring the body composition by standing on the body composition analyzing apparatus according to the present invention;

FIG. 2 schematically illustrates impedance models of the human body to be measured by the apparatus according to the present invention;

FIG. 3 illustrates the circuit of the body composition analyzing apparatus according to the present invention; and

FIGs. 4A to 4H illustrate electrical connections for the measurement of segmental body impedances according to the present invention.

Detailed Description of the Preferred Embodiment

FIG. 1 is a schematic view showing a person measuring the body composition by standing on the body composition analyzing apparatus according to the present invention.

The apparatus of the present invention includes: a right palm electrode E1 for being surrounded by a right hand and the fingers excluding the right thumb; a right thumb electrode E2 for contacting with only a right thumb; a left palm electrode E3 for being surrounded

by a left palm and the left fingers excluding the left thumb; a left thumb electrode E4 for contacting only with a left thumb; a right front sole electrode E5 for contacting only with a right front sole; a right rear sole electrode E6 for contacting only with a right rear sole; a left front sole electrode E7 for contacting only with a left front sole; and a left rear sole electrode E8 for contacting only with a left rear sole.

Thus, the body composition analyzing apparatus according to the present invention includes 8 electrodes for contacting with 8 extremity portions of the human body, respectively. A person to be measured stands on the apparatus in an upright posture, and in this state, the hands and feet are contacted to the metal electrodes. Therefore, the impedance measurement can be carried out in a convenient manner.

The apparatus of the present invention is provided with 8 electrodes to contact with 8 portions of the human body as described above, and the impedance model of the human body is as shown in FIG. 2.

FIG. 2 schematically illustrates segmental impedance models to be used by the apparatus according to the present invention.

It will be indicated as follows. That is, the resistance from the right wrist to the joint of the right shoulder is indicated by R1, the resistance from the left wrist to the joint of the left shoulder is indicated by R2, the resistance from the right ankle to the joint of the right hip joint is indicated by R3, the resistance from the left ankle to the joint of the left hip joint is indicated by R4, the resistance of the trunk is indicated by R5, the resistance from the palm to the wrist is indicated by Ra, the resistance from the thumb to the wrist is indicated by Rb, the resistance from the front sole to the ankle is indicated by Rc, and the resistance from the rear sole to the ankle is

indicated by Rd.

FIG. 3 illustrates the circuit of the body composition analyzing apparatus according to the present invention.

The apparatus for analyzing the body composition based on the bioelectrical impedance method according to the present invention includes:

a plurality of electrodes E1-E8 for contacting with a right palm, a right thumb, a left palm, a left thumb, a right front sole, a right rear sole, a left front sole, and a left rear sole, respectively;

an impedance measuring instrument 11 for measuring the impedance based on a voltage-current ratio by injecting an alternating current between two electrodes and by reading the voltage difference between two electrodes;

an electronic switch 10 for being controlled by a micro-processor to select electrical connections between the electrodes E1-E8 and the impedance measuring instrument 11;

a weight measuring sensor 18 for measuring the body weight of the person to be measured:

a keyboard 15 for inputting the body height, age and sex of the person to be measured;

an A/D converter 13 and amplifiers 12 and 19 for interfacing the impedance measuring instrument 11 and the weight sensor 18 to the micro-processor 14;

the micro-processor 14 for controlling the electronic switch 10 and for processing the data received from the impedance measuring instrument 11 and the keyboard 15; and

a display unit 16 for displaying the processed results.

The apparatus of the present invention is provided with a weight measuring sensor 18 so as to make it possible to measure the body weight of a person. The information on the body weight thus

measured is inputted into the micro-processor 14, and then, the body height, age and sex are entered through the keyboard 15, so that the micro-processor 14 can compute the amount of the body fluid (TBW), fat free mass (FFM), and the percent body fat (% BF).

In the body composition analyzing apparatus of the present invention, the results processed by the micro-processor 14 are displayed on the display unit 16, and when needed, a printer 17 is added for printing the data.

FIGs. 4A to 4H illustrate electric circuits representing the segmental impedances of a human body to be measured according to the present invention.

Referring to FIGs. 2 and 4, the resistances of the different body segments R1, R2, R3, R4 and R5 will be described in detail as to how they are measured.

As shown in FIG. 4A, the electronic switch 10 is on for electrodes E2 and E4 by a command of the micro-processor 14, so that an electric current generated from the impedance measuring instrument 11 would flow between the electrodes E2 and E4. Further, the electronic switch 10 is connected between electrodes E1 and E5 by a command of the micro-processor 14, so that the voltage between the electrodes E1 and E5 can be measured. Thus the resistance R1 can be measured from the above mentioned current and voltage.

As shown in FIG. 4B, the electronic switch 10 is connected between electrodes E1 and E3 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E1 and E3. Further, the electronic switch 10 is connected between electrodes E2 and E6 by a command of the micro-processor 14, so that the voltage between the electrodes E2 and E6 can be measured. Then the value of the resistance R1 can be measured from the current and voltage.

Another method for measuring R1 is possible. As shown in FIG. 4C, the electronic switch 10 is connected between electrodes E2 and E4 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E2 and E4. Further, the electronic switch 10 is connected between electrodes E1 and E8 by a command of the micro-processor 14, so that the voltage between the electrodes E1 and E8 can be measured. Then the value of the resistance R1 can be measured from the current and voltage.

Another method for measuring R1 is possible. As shown in FIG. 4D, the electronic switch 10 is connected between the electrodes E2 and E4 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E2 and E4. Further, the electronic switch 10 is connected between electrodes E3 and E7 by a command of the micro-processor 14, so that the voltage between the electrodes E3 and E7 can be measured. Then the value of the resistance R2 can be measured from the current and the voltage.

As shown in FIG. 4E, the electronic switch 10 is connected between electrodes E4 and E8 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E4 and E8. Further, the electronic switch 10 is connected between electrodes E1 and E5 by a command of the micro-processor 14, so that the voltage between the electrodes E1 and E5 can be measured. Then the value of the resistance R5 can be measured from the current and the voltage.

As shown in FIG. 4F, the electronic switch 10 is connected between electrodes E6 and E8 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E6 and E8. Further,

the electronic switch 10 is connected between electrodes E1 and E5 by a command of the micro-processor 14, so that the voltage between the electrodes E1 and E5 can be measured. Then the value of the resistance R3 can be measured from the current and the voltage.

As shown in FIG. 4G, the electronic switch 10 is connected between electrodes E6 and E8 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E6 and E8. Further, the electronic switch 10 is connected between electrodes E3 and E7 by a command of the micro-processor 14, so that the voltage between the electrodes E3 and E7 can be measured. Then the value of the resistance R4 can be measured from the current and the voltage.

As shown in FIG. 4H, the electronic switch 10 is connected between electrodes E2 and E4 by a command of the micro-processor 14, so that a current generated from the impedance measuring instrument 11 would flow between the electrodes E2 and E4. Further, the electronic switch 10 is connected between electrodes E3 and E7 by a command of the micro-processor 14, so that the voltage between the electrodes E3 and E7 can be measured. Then the value of the resistance of the whole human body can be measured from the current and the voltage.

FIGs. 4A to 4H illustrate only exemplary cases for measuring the segmental impedances by making a current flow between two electrodes among the electrodes E1 to E8 and by measuring the voltage between other two electrodes. Besides these examples, there can be other connections of measuring the impedances of the body segments.

In the present invention, the impedance measuring instrument 11 is connected to the eight electrodes E1-E8. The eight electrodes E1-E8 serve as current electrodes or voltage electrodes. The electrode

E1 and the electrode E2 are connected by the electronic switch 10 by a command of the micro-processor 14, in such a manner that they should serve different functions. For example, if the electrode E1 is a current electrode, then the electrode E2 is a voltage electrode, while if the electrode E2 is a current electrode, the electrode E1 is a voltage electrode. The electrodes E3 and E4 are also used in such a manner that they should serve different functions, and the electrodes E5 and E6 are also used in the same manner, while the electrodes E7 and E8 are also used in the same manner.

That is, each electrode E1-E8 serves as either a current electrode or a voltage electrode. As shown in FIG. 3, if the electrodes E1, E3, E5 and E7 are used as current electrodes, then the electrodes E2, E4, E6 and E8 are used as voltage electrodes. On the other hand, if the electrodes E2, E4, E6 and E8 are used as current electrodes, then the electrodes E1, E3, E5 and E7 are used as voltage electrodes.

In the impedance measuring method of the present invention, the variations in the values of the resistances Ra, Rb, Rc and Rd do not affect the measured values of the segmental impedances. That is, when a person to be measured steps on the electrodes E5-E8 with the both feet, and grips the electrodes E1-E4 with the both hands, even if the contact positions between the electrodes and the body are slightly shifted, it does not affect the measured resistance values R1-R5.

In measuring the impedances of the different body segments, the electrical connections between the electrodes E1-E8 and the impedance measuring instrument 11 have to be changed many times based on the segmental measurement described above. In order to automatize this, there is the electronic switch 10 which is opened/closed by the micro-processor 14.

Meanwhile, the body weight is measured by a weight measuring sensor 18 which is placed under the foot electrodes E5-E8

of the body composition analyzing apparatus of the present invention. The measured body weight is transferred through the amplifier 19 and the A/D converter 17 to the micro-processor 14. The resistance values R1-R5 which are measured by the impedance measuring instrument 11 also are transferred through the amplifier 12 and the A/D converter 17 to the micro-processor 14.

Then body height, age and sex are inputted through the keyboard 15, and these data are transferred through an interface to the micro-processor 14. Based on the impedances, the body height, weight, age and sex which are stored in the micro-processor 14, the body composition such as the amount of the body fluid (TBW), the fat free mass (FFM), the body fat proportion(% BF), and the body fluid distribution ratio inside and outside the cells are analyzed. The analyzed results are displayed on the display unit 16, and printed by the printer 17.

Examples for computing the body composition from the measured impedances are as follows. It is assumed that the left and right arms and legs and the trunk are five cylindrical conductors which have uniform cross sectional areas and which are similar in length. Based on this assumption, the impedances R1-R5 are measured. The parallel connection value Rarm for the both arms is defined as follows.

$$Rarm= (R1 \times R4) / (R3+R4) \qquad (\mathrm{I})$$

The parallel connection value Rleg for the both legs is defined as follows.

$$Rleg= (R3 \times R4) / (R3+R4) \qquad (\mathrm{II})$$

The resistance value for the trunk Rtrunk is defined to be R5.

The amount of water contained in a body segment is proportional to Ht^2/R, where R indicates the impedance value for the relevant body segment, and Ht indicates the body height of the measuring person.

The total body water (TBW) is the sum of the segmental water, and is defined as follows.

$$TBW = C_1 \cdot Ht^2/Rarm + C_2 \cdot Ht^2/Rleg + C_3 \cdot Ht^2/Rtrunk + C_4 \quad (III)$$

In Formula III above, C_1, C_2, C_3 and C_4 are the best suitable constants, and can be obtained from TBW which is obtained by a heavy water dilution method (D_2O dilution).

Formula III is stored in the micro-processor 14, and therefore, TBW can be obtained from the calculated Rarm, Rleg, Rtrunk and Ht.

In addition to these variables, sex and age can be used as additional valuables.

$$TBW = C_1 \cdot Ht^2/Rarm + C_2 \cdot Ht^2/Rleg + C_3 \cdot Ht^2/Rtrunk + C_4 \cdot Sex + C_5 \cdot Age + C_6 \quad (IV)$$

In the above formula, Sex is 0 for female, and 1 for male, while Age is the age of the person to be measured.

The fat free mass (FFM) contains about 73% of water, and therefore, FFM is defined as follows.

$$FFM = TBW/0.73 \quad (V)$$

Body fat contains relatively small amount of water, and therefore, this water content is disregarded. Thus, the amount of

body fat (FAT) is defined to be the weight (Wt) minus FFM, and is defined by Formula VI, thus percent body fat (% BF) is defined by Formula VII.

$$FAT = Wt - FFM \qquad (VI)$$

$$\% BF = (Wt-FFM) \times 100/Wt \qquad (VII)$$

According to the present invention as described above, even without assistance of a specially trained person, the person to be measured can stand with the two legs on the foot electrodes, and can grasp the hand electrode rods with two hands, so that the right palm, the right thumb, the left palm, the left thumb, the right front sole, the right rear sole, the left front sole and the left rear sole would be contacted with 8 different electrodes. Thus the impedances of the different body portions are automatically measured by the eight electrodes, and the body composition is analyzed in a precise and simple manner.

It should be apparent to those skilled in the art that various changes and modifications can be added to the present invention without departing from the scope of the present invention which is limited only by the appended claims.

What is claimed is:

1. A method for determining segmental body impedances for body composition based on bioelectrical impedance measurement, comprising the steps of:

(a) providing eight electrodes E1-E8 for being contacted to a right palm, a right thumb, a left palm, a left thumb, a right front sole, a right rear sole, a left front sole and a left rear sole;

(b) providing electrical contacts between a person to be tested and said electrodes E1-E8 by gripping palm and thumb electrodes E1-E4 with hands and by stepping front and rear sole electrodes E5-E8 with bare feet;

(c) connecting two current electrodes out of said electrodes E1 or E2, E3 or E4, E5 or E6, and E7 or E8 with an electronic switch 10 by a command a micro-processor 14 thereby injecting an alternating current between said two electrodes;

(d) connecting two voltage electrodes, excluding said two current electrodes of (c), out of said electrodes E1 or E2, E3 or E4, E5 or E6, and E7 or E8 with said electronic switch by a command said micro-processor thereby measuring voltage difference between the segmental bodies selected by said two voltage electrodes;

(e) determining segmental impedance R1, R2, R3, R4 or R5 between segmental bodies based on the current and voltage measured by an impedance measuring instrument 11; and

(f) repeating the steps from (c) to (e) so as to measure segmental impedances for right arm R1, left arm R2, right leg R3, left leg R4, and trunk R5.

2. The method as claimed in claim 1, wherein said electrodes E1, E3, E5 and E7 are used as current electrode, and wherein said

electrodes E2, E4, E6 and E8 are used as voltage electrode.

3. The method as claimed in claim 1, wherein said electrodes E1, E3, E5 and E7 are used as voltage electrode, and wherein said electrodes E2, E4, E6 and E8 are used as current electrode.

4. A method for determining body composition based on bioelectrical impedance measurement, comprising the steps of:

(a) providing eight electrodes E1-E8 for being contacted to a right palm, a right thumb, a left palm, a left thumb, a right front sole, a right rear sole, a left front sole and a left rear sole;

(b) providing electrical contacts between a person to be tested and said electrodes E1-E8 by gripping palm and thumb electrodes E1-E4 with hands and by stepping front and rear sole electrodes E5-E8 with bare feet;

(c) connecting two current electrodes out of said electrodes E1 or E2, E3 or E4, E5 or E6, and E7 or E8 with an electronic switch 10 by a command a micro-processor 14 thereby injecting an alternating current between said two electrodes;

(d) connecting two voltage electrodes, excluding said two current electrodes of (c), out of said electrodes E1 or E2, E3 or E4, E5 or E6, and E7 or E8 with said electronic switch by a command said micro-processor thereby measuring voltage difference between the segmental bodies selected by said two voltage electrodes;

(e) determining segmental impedance R1, R2, R3, R4 or R5 between segmental bodies based on the current and voltage measured by an impedance measuring instrument 11;

(f) repeating the steps from (c) to (e) so as to measure segmental impedances for right arm R1, left arm R2, right leg R3, left leg R4, and trunk R5; and

(g) calculating body composition based on the measured segmental impedances.

5. The method as claimed in claim 4, further comprising the step of measuring body weight by means of a weight measuring sensor 18, thereby the body weight being entered into said micro-processor.

6. The method as claimed in claim 5, further comprising the step of inputting body height, age and sex of a person to be tested through a keyboard 15 into a micro-processor 14.

7. The method as claimed in claim 6, further comprising the step of displaying the results of body composition to a display unit 16.

8. The method as claimed in claim 7, further comprising the step of printing the results of body composition with a printer 17.

9. An apparatus for determining body composition based on a bioelectrical impedance method, comprising:

eight metal plate electrodes E1-E8 for being contacted to a right palm E1, a right thumb E2, a left palm E3, a left thumb E4, a right front sole E5, a right rear sole E6, a left front sole E7, and a left rear sole E8, respectively;

an impedance measuring instrument 11 for measuring the impedances for the segmental bodies on the basis of an alternating current injected between two current electrodes out of said electrodes E1 or E2, E3 or E4, E5 or E6, and E7 or E8, and of voltage difference measured between the segmental bodies selected by two voltage electrodes, excluding said two current electrodes of (c), out of said

electrodes E1 or E2, E3 or E4, E5 or E6, and E7 or E8;

an electronic switch 10 for being controlled by a micro-processor 14 to connect said two current electrodes and said two voltage electrodes, respectively;

an A/D converter 13 and amplifiers 12 and 19 for interfacing said impedance measuring instrument 11 to said micro-processor 14: and

said micro-processor 14 controlling said electronic switch 10 and processing the data received from said impedance measuring instrument 11.

10. The apparatus as claimed in claim 9, further comprising a weight measuring sensor 18 for measuring a body weight of a person to be tested.

10. The apparatus as claimed in claim 10, further comprising a keyboard 15 for inputting the body height, age, and sex of a person to be tested.

12. The apparatus as claimed in claim 11, further comprising a display unit 16 for displaying the results processed by said micro-processor 14.

13. The apparatus as claimed in claim 12, further comprising a printer 17 for printing the results processed by said micro-processor 14.

Fig. 1

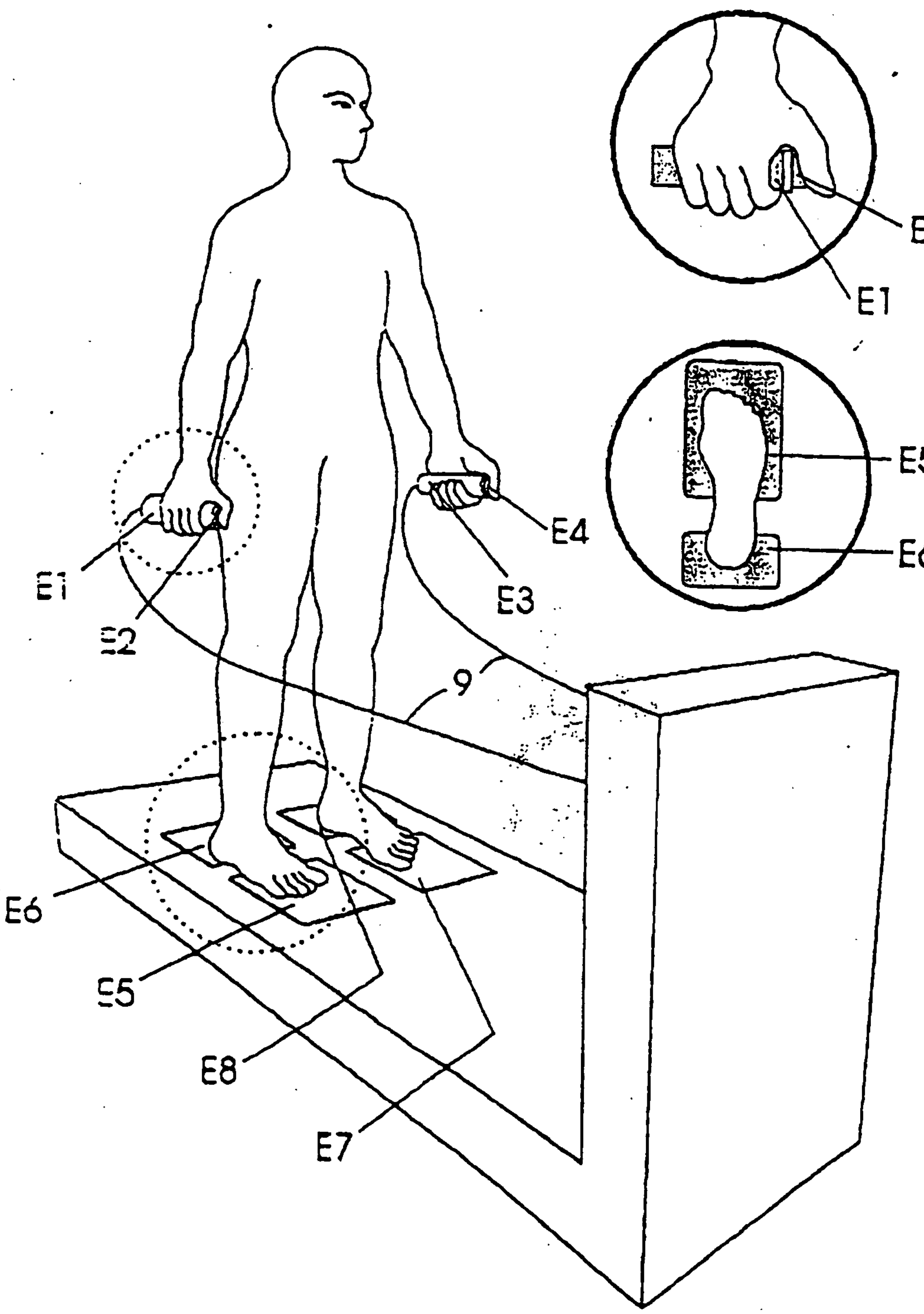


Fig. 2

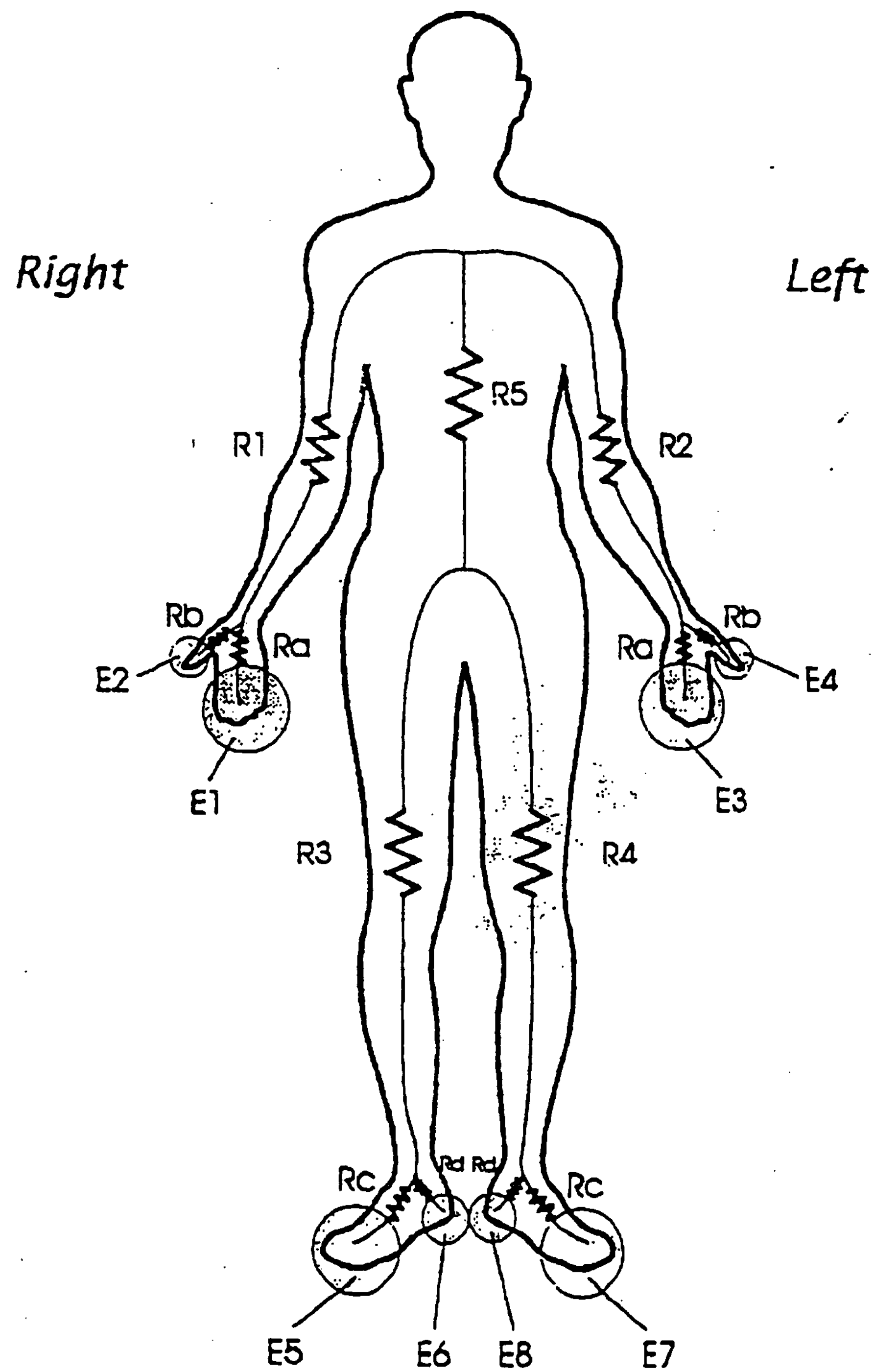
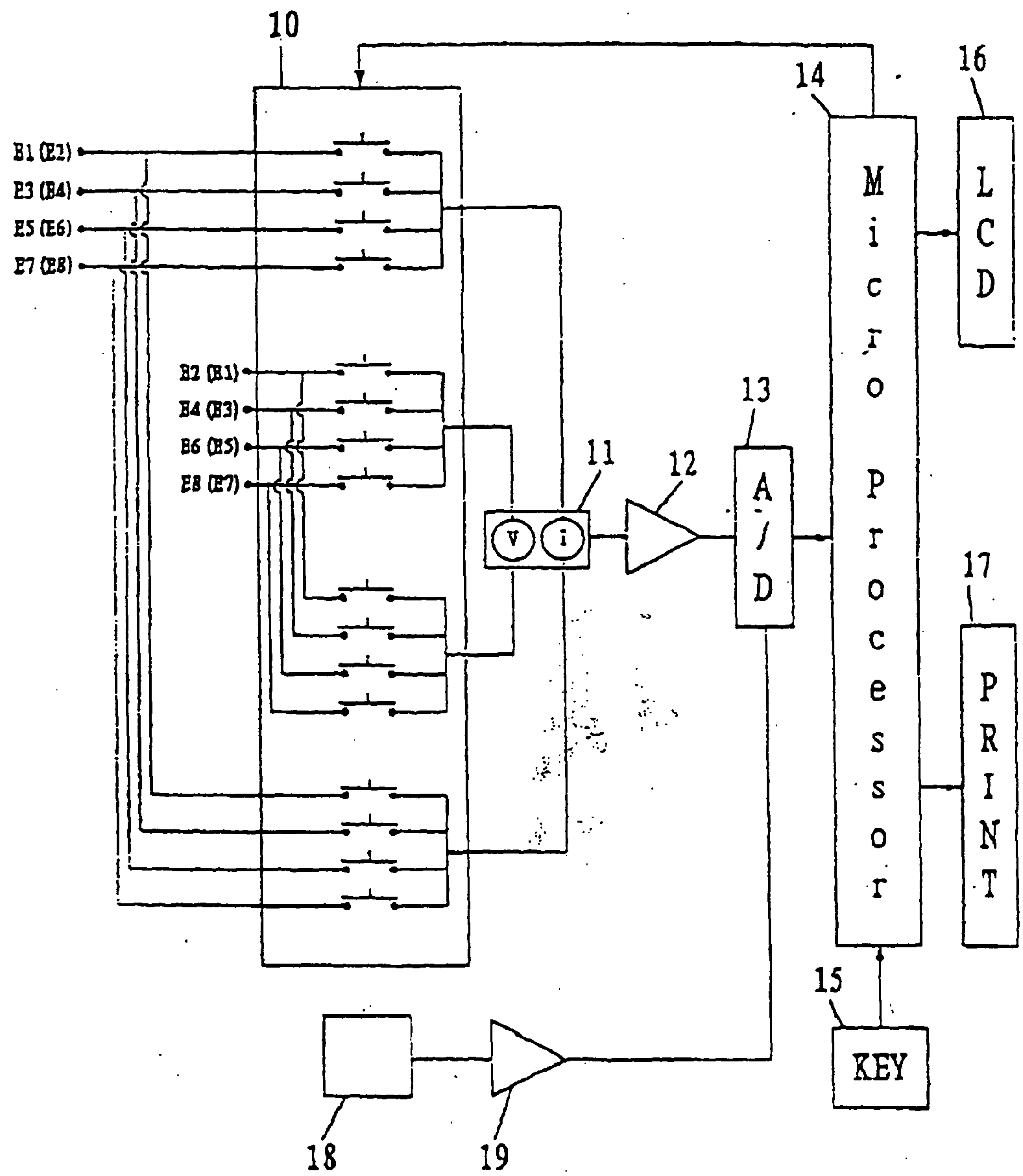

Right
Left
R5
R1
R2
Rb
Ra
E2
E1
Ra
Rb
E4
E3
R3
R4
Rc
Rd
Rd
Rc
E5
E6
E8
E7

Fig. 3



10
14
16
E1 (E2)
E3 (E4)
E5 (E6)
E7 (E8)
E2 (E1)
E4 (E3)
E6 (E5)
E8 (E7)
Micro processor
LCD
13
11
12
V
i
A/D
17
PRINT
15
KEY
18
19

Fig. 4E

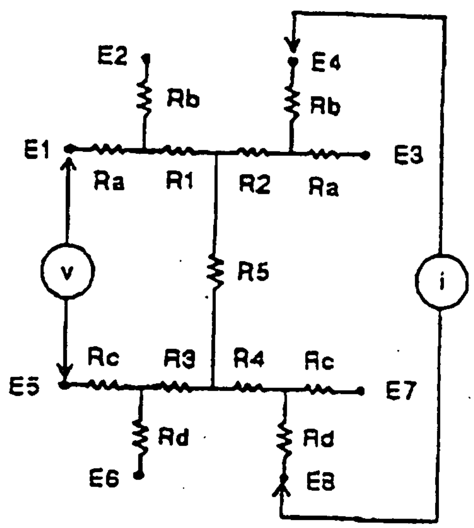


Fig. 4F

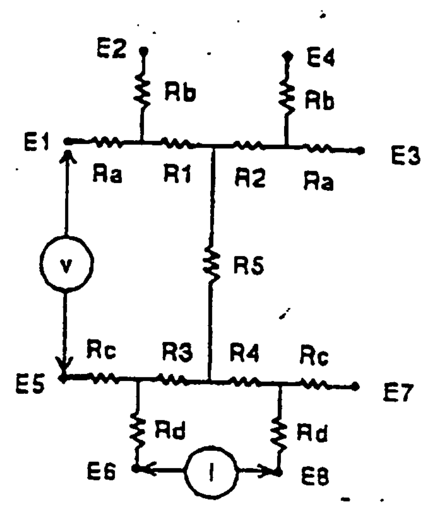


Fig. 4G

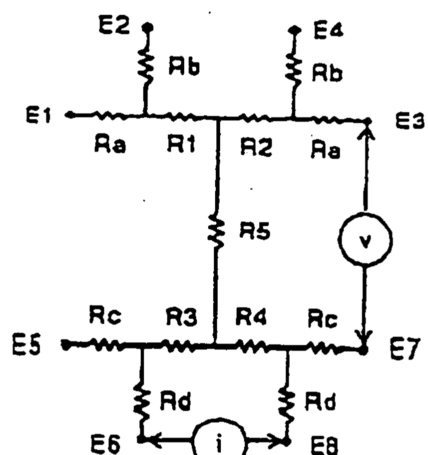
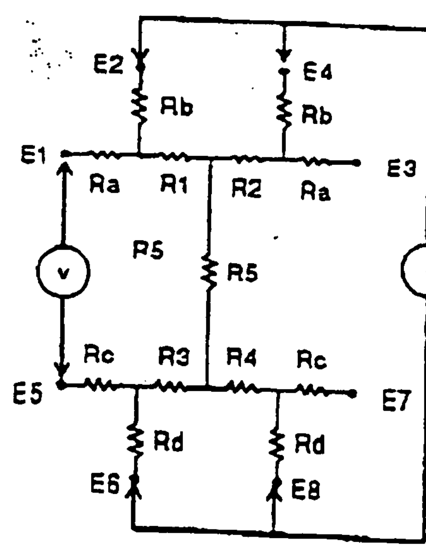


Fig. 4H



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 96/00092

A. CLASSIFICATION OF SUBJECT MATTER

IPC^6: A 61 B 5/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC^6: A 61 B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPOQUE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 698 779 A1 (EUGEDIA) 10 June 1994 (10.06.94), abstract; page 2, lines 13-27; page 4, lines 12-31; page 5, lines 7-19; claims 1-7; fig.1.	1,4-7,9-12
A	US 4 793 362 A (TEDNER) 27 December 1988 (27.12.88), abstract; fig.1; column 1, lines 24-42; column 2, lines 21-30,64-66.	1,2,4,6,9,11
A	US 4 947 862 A (KELLY) 14 August 1990 (14.08.90), abstract; fig.1,2; column 3, lines 63-68; column 4, lines 60-65.	1,4-7,9,11,12
A	US 5 335 667 A (CHA) 09 August 1994 (09.08.94), abstract; fig.1,3a; column 3, lines 10-24; column 4, lines 55-68.	1,2,4,9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 1996 (31.10.96)	13 November 1996 (13.11.96)

Name and mailing address of the ISA/AT	Authorized officer
AUSTRIAN PATENT OFFICE Kohlmarkt 8-10	Zawodsky

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR 96/00092

Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
FR A1 2698779	10-06-94	FR B1 2698779	13-01-95
US A 4793362	27-12-88	DE C0 3364881	04-09-86
		EP A1 106867	02-05-84
		EP B1 106867	30-07-86
		JP T2 59500700	26-04-84
		SE A 8202533	23-10-83
		SE B 455043	20-06-88
		SE C 455043	29-09-88
		WO A1 8303746	10-11-83
US A 4947862	14-08-90	keine - none - rien	
US A 5335667	09-08-94	keine - none - rien	